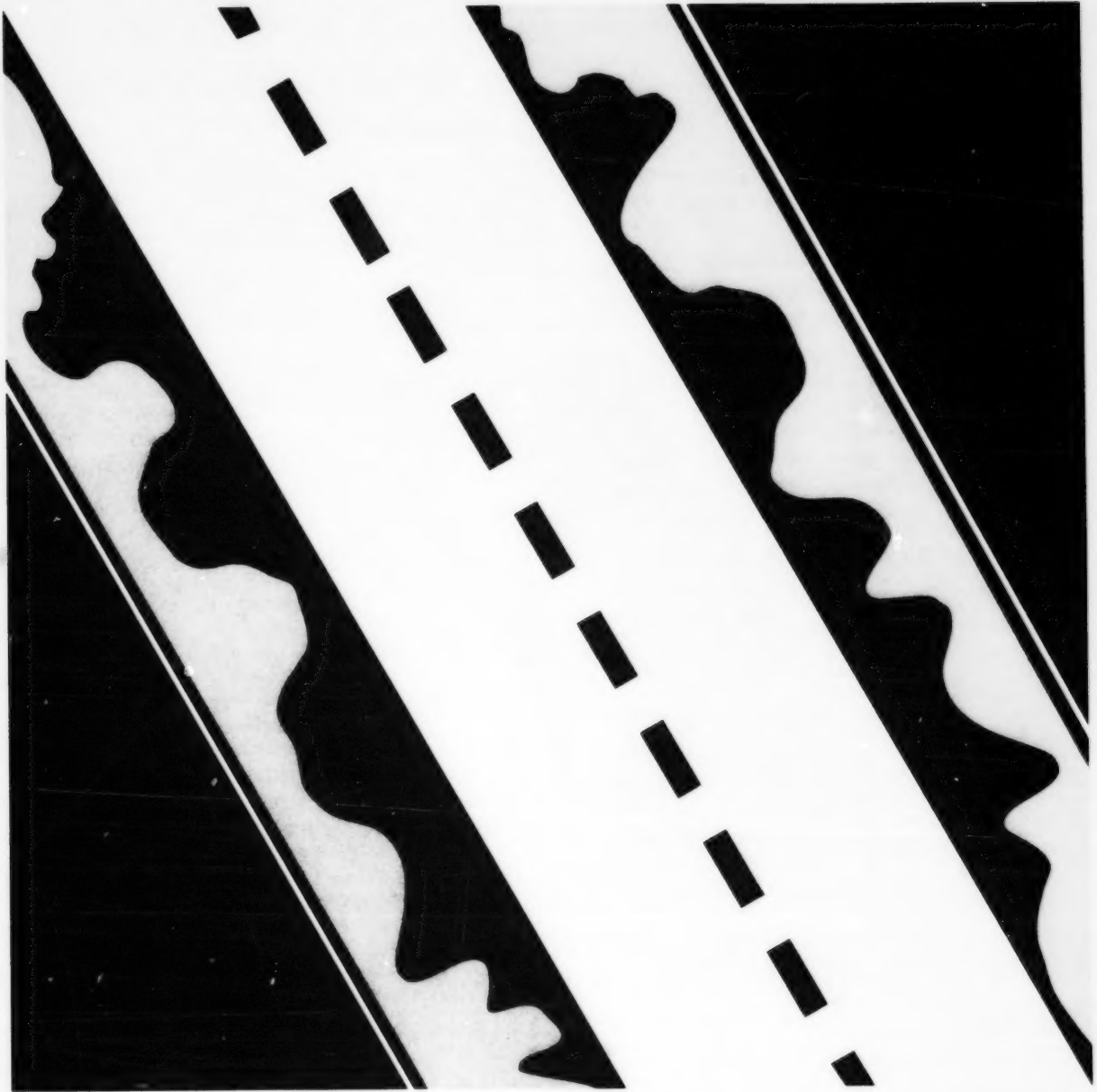


Review of Existing Vegetation Management Practices and Identification of Future Research Needs



Ministry
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Review of Existing Vegetation Management Practices and Identification of Future Research Needs

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Abstract: This report documents a review of the roadside vegetation management program of the Ontario Ministry of Transportation in light of economic pressures and environmental concerns. Experience in Ontario and other jurisdictions is reviewed to identify programs that could meet these challenges. Current vegetation management strategies include horticultural plantings, natural landscapes and encouragement of natural regeneration.

The implications of different policy options were considered and a benefit-cost analysis was prepared before determining which policy options should be recommended.

The report recommends that the Ministry view the highway right-of-way as a location where sustainable development can be demonstrated. The public could provide philosophical support and assist in actual roadside activities where feasible. Co-operative management projects could involve the public in right-of-way vegetation operations in specific settings.

Pesticide use should be optimized by reducing its use where practical, developing and implementing integrated pest management systems and optimizing maintenance programs to reduce weed growth. Increasing low maintenance plantings, ensuring survival of plantings and expanding natural regeneration will contribute to long-term optimization of maintenance operations. Improving the aesthetics of highway rights-of-way can be accomplished through other recommended policy options.

Research is outlined that would aid in implementation of these programs.

Comments: Research in 1990 is focusing on integrated weed management establishment techniques for wild-flowers and direct rooting of cuttings on highway rights-of-way.

Key Words: Highway vegetation management, landscape maintenance, weed control, brush control, integrated pest management, natural regeneration, co-operative management, cost-benefit

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1/ Introduction

The Ontario Ministry of Transportation (MTO) has recognized the need to review its current roadside vegetation management practices and to outline its vegetation management research needs over the next five to ten years.

There have been recent changes in policy and vegetation management practices on the part of several public agencies in Ontario. The public's interest in the management of highway rights-of-way has also increased. For example, there are groups which suggest that these open spaces could be managed to encourage wildflowers; others have suggested that forage crops be planted¹.

The broad acceptance of the sustainable development concept has initiated a review of a variety of environmental management practices in the public and private sectors. Methods of maximizing productivity while minimizing environmental impact and economic cost are being sought in all sectors, e.g. the agricultural industry and utility companies.

The Ministry has demonstrated flexibility in vegetation management approaches in the past. The natural regeneration program was an example of a practice designed to reduce maintenance costs while enhancing environmental quality.

The Ministry has recognized the merits of a periodic review of its vegetation management program. In 1977, the Ministry published *Roadside Vegetation Management in Ontario*, by Andresen and Lewis-Watts [1]. This report focused on the survival of trees and shrubs planted by the Ministry and on the benefits of natural regeneration as a roadside management method. Since the 1977 report there has not been a comprehensive review of roadside vegetation management options.

The Ministry has, however, been active in funding research which would assist in solving specific types of roadside management problems. Research on the following topics has been supported:

- bioengineering
- wildflower plantings
- testing of species for erosion control on dry, sandy slopes
- testing of hydroseeding methods

- development of pesticide application technology
- evaluation of vegetation control products.

Currently, there is no long-range plan to aid in selection of research topics, nor is research being focused to facilitate implementation of specific policy directions.

1.1/ Study Objectives

The study had four primary objectives:

- Examine the Ministry's vegetation management standards and practices, literature, and activities in comparable jurisdictions.
- Formulate policy options for vegetation management and examine the cost-benefit implications of each option.
- Prepare a research plan detailing projects in support of the policy option(s) deemed most appropriate.
- Prepare a final report documenting the results of the study.

¹Personal communication with H. Rudy, Land Stewardship Program, Ontario Ministry of Agriculture and Food.

2/ Study Methods

Descriptions of current Ministry vegetation management practices were available in maintenance quality standards and specifications [2, 3, 4, 5, 6, 7, 8]. Discussions with Ministry staff in the Districts and Maintenance Branch provided insight into these current practices. Areas focused on included current problems facing vegetation managers, trends and changes in interaction with the public, technical information flow and staff training. This analysis revealed where improvements could be made in the current programs.

Interviews with vegetation managers employed in other Ontario jurisdictions, other provinces and in the United States provided the opportunity to determine the level of success associated with alternative approaches.

A literature review provided a variety of information including:

- technical information on management techniques
- cost and effectiveness data on specific techniques
- descriptions of new methods
- indications of public concerns
- policies and programs in other jurisdictions

This information provided ideas on alternative approaches which could be considered in Ontario.

2.1/ Identify Policy Options

Once all of the input was assembled and considered, potential policy options were formulated. Research needs which would facilitate implementation of the recommended policy options were identified. A research plan for the next five years was developed.

2.2/ Benefit-Cost Analysis

In order to effectively evaluate the various vegetation management options, programs, and projects presented, an assessment of benefits relative to costs was required. Alternative practices and their predicted costs and benefits were compared to current Ministry practices and the experiences or trends reported from other jurisdictions. Cost implications were determined for the recommended policy options (see Appendix A).

3/ Findings

3.1/ Ministry Standards and Practices

The goals of the Ministry's highway right-of-way vegetation management programs include the following:

- to ensure safe motoring
- to protect highway infrastructure
- to meet legal obligations, e.g. Weed Control Act
- to optimize environmental quality
- to ensure staff safety
- to maximize cost-effectiveness of maintenance operations.

The key components of any vegetation management program to achieve these goals include:

- monitoring and applying technological developments and products
- improving designs of right-of-way plantings
- adapting maintenance and operations methods
- staff training/technical support
- managing relations with the public
- conducting research
- responding to changes in funding
- responding to changes in public concerns

A discussion of each of these program components provides the opportunity to evaluate the Ministry's vegetation management program relative to that of other jurisdictions. This exercise will assist in identifying any changes in current programs which could be addressed when formulating policy options.

3.1.1/ Differences in Program Requirements for Northern and Southern Ontario

Different soil and vegetation conditions across Ontario affect the nature of the vegetation management tasks and methods which must be applied to achieve appropriate levels of management. The Canadian Shield, roughly equated with *northern Ontario*, and off-shield areas, roughly equated with *southern Ontario*, are the two most distinctive components of the landscape crossed by most provincial highways.

Brief descriptions of the differences in vegetation management in these two areas follow.

Northern Ontario

Here, with the exception of Claybelt areas, the terrain is rocky; soils are generally shallow and forests flank the highways. The main challenge is to keep brush and regenerating trees from encroaching on highway rights-of-way. This vegetation control is necessary to preserve sight lines and to maintain drainage by keeping ditches free of brush.

Due to the nature of the vegetation to be controlled and the extensive areas involved, there is a reliance on chemical brush control. Usually a three to six year spray rotation is used.

Since there is little agricultural land or urban area adjacent to most rights-of-way in the north, weed control is not a significant issue. There is virtually no planting or tending of landscape stock in northern Ontario.

Public concern about the Ministry's vegetation control program is limited to local interest in weed control in agricultural areas and site-specific concern about spraying near private property.

Southern Ontario

This portion of Ontario is dominated by mixed or hardwood forest, where it has not been cleared for agricultural, industrial or residential use. Since soils are generally deeper and right-of-way geometry can be shaped, grass mixes are usually seeded following highway construction. Mowing occurs routinely and, because of the preponderance of agricultural and urban land uses, weed control is a significant issue. Weed control relies heavily upon broadcast herbicide spraying, but some spot and wick application is employed. In some cases, mowing provides a measure of weed control.

Natural regeneration has been allowed to occur adjacent to woodlots and wetlands where the potential for impact on agricultural land is minimized. The requirement for mowing is reduced along rights-of-way which are managed for natural regeneration.

Planting and tending of trees and shrubs along the rights-of-way is a significant activity, especially in urban areas. These plantings require watering and fertilization, particularly during the first three years, and pruning to maintain sight lines.

3.1.2/ Monitoring and Applying Technological Developments and Products

The Ministry monitors the development of new equipment, erosion control materials, and chemicals available for right-of-way management. Research is also conducted into other methods of vegetation management and cultural practices. Examples of topics currently receiving attention include wild-flower plantings and integrated weed management.

The Ministry has put considerable effort into applying methods which reduce pesticide spray drift. New spray nozzle technology and application gauged to groundspeed has been tested and used in the Districts. Tractor-mounted wick applicators have been introduced in recent years.

There is an ongoing review of chemicals and technology. The choice of chemicals used in weed and brush control is continually updated. As new methods are proven and made available, they are used by the Ministry. The Ministry faces some limitations in its application of technological advances in that certain herbicides which are available in the United States are not registered for use in Canada.

3.1.3/ Improving Designs of Right-of-Way Plantings

Highway design responds to a number of competing pressures, often resulting in long-term vegetation maintenance problems. In some locations large steep slopes are created when new highways are designed. These slopes may erode; they are difficult to mow and, unless they are planted with trees and shrubs, they can be unsightly. Also, the quality of soils in which roadside vegetation is planted is frequently poor.

There is a rather limited variety of ground cover, shrub and tree species available to the highway landscape designer in Ontario. Variety development is not geared to use along highways. Although the soils and climate vary greatly throughout the province, the basic cover treatment available to the designer is the standard MTO seed mix. This mix contains 55% creeping red fescues, 25% Canada or Kentucky bluegrass, 12% perennial rye grass, 5% red top and 3% white clover. Other seed mixes are used on a site-specific basis.

Implementation of the planting design is part of the Provincial Highway Program's capital construction project. However, the longer term responsibility for survival and maintenance of the vegetation becomes the responsibility of the District staff. There is little staff continuity from design, through planting, through long-term maintenance.

The use of low maintenance plantings (e.g. crown vetch, sumac) in suitable locations is an example of

improved planting design approaches which have been implemented in certain locations.

3.1.4/ Adapting Maintenance and Operations Methods

Following periodic reviews of specific practices, the Ministry has revised maintenance specifications. One of the major changes in vegetation management was the shift to reduced mowing in the late 1970's. This led to extensive areas of natural regeneration. Since that time the area of mowing in Ontario has remained the same and there appears to have been a very limited effort to reduce the area of mowing further.

Along the multi-laned, limited access highways, there are still extensive areas of mowed right-of-way where less intensive management could be used. Some of these areas are in urban settings or on the urban fringe and are adjacent to commercial and industrial lands. Staff training and public education would be required along with a gradual reduction in the frequency and/or height of mowing to facilitate an acceptable change in management practices in these areas.

There are a number of improvements which could be made in current maintenance and operations practices. In his 1977 review report, Andresen recommended that more attention be given to the problem of high mortality in tree and shrub plantings. This problem still exists. It appears that lack of watering during the past dry summers (1988, 1989) has been a significant problem. Lack of manpower and/or equipment are cited as the reasons for lack of remedial action.

Judgement and experience are critical when making decisions regarding implementation of maintenance specifications at the local level. For example, certain levels of weed cutting, mowing frequency and mowing height can create conditions which stress grasses and favour weed growth.

3.1.5/ Staff Training/Technical Support

The level of Ministry staff training and technical support varies among the Districts. There are bi-yearly sessions where all District staff involved in vegetation management review methods and procedures. Training in pesticide application is arranged at the District level. As well, some staff have horticultural backgrounds and may belong to professional associations.

The level of training influences the quality of decisions which are made about problem solving, resource use and implementation of new methods. If significant changes which involve cultural methods and horticultural approaches are to be made, staff training will be necessary. Technology transfer conferences, field trips, demonstration plots and a

vegetation management newsletter are all potential training methods.

Technical support is available from the Maintenance Branch. In addition, some Districts develop a local network for support (e.g. with universities, Ontario Ministry of Agriculture and Food, and the Ontario Ministry of Natural Resources).

3.1.6/ Managing Relations with the Public

Currently, there is no proactive contact with the public. The public does not have a broad understanding of the goals and limitations of the Ministry highway vegetation management program.

During most contacts Ministry staff are in the position of responding to questions, concerns or complaints although District staff are not trained to deal with public inquiries. If a more effective approach is to be pursued, staff training will be required.

3.1.7/ Research Program

Examples of past research which have influenced subsequent vegetation management practices includes work on natural regeneration and spray equipment. The Ministry has also been reviewing the American experience with wildflowers as a highway right-of-way vegetation treatment.

Currently, research needs are identified annually. Unsolicited research proposals are also considered for funding. There is a need for a long-range plan regarding research needs, so that the results will contribute to achieving goals for new developments or improvements in vegetation management.

3.1.8/ Responding to Changes in Funding

It is not expected that funds for vegetation management on highway rights-of-way will increase in the future. Past reductions in funding resulted in greater areas of natural regeneration and reductions in mowing. In many locations, however, weed control has continued to be a cost on natural regeneration sites.

With reduced maintenance staff numbers, the current challenge for supervisors is to manage staff time efficiently so that the full range of vegetation management activities receives attention at the appropriate time.

Spraying remains the most cost-effective method of control for weeds in turf areas and for brush control on northern rights-of-way. Watering trees and shrubs is an activity which seems to lose out in many Districts resulting in high mortality of planted material, particularly in dry years such as 1988 and 1989.

3.1.9/ Responding to Public Concerns

The use of pesticides in highway vegetation management is an area of public concern, especially to landowners whose property abuts the Ministry's rights-of-way.

The Ministry has always placed emphasis on the safe use of chemical sprays. Staff are trained in correct procedures for chemical application and records are kept of all spraying. The pesticides that are used have been screened for environmental safety and persistence and have the least impact on non-target vegetation. As new chemicals become available for use in Ontario, the Ministry assesses their potential for use in highway right-of-way vegetation management.

It is important to recognize that the Ministry must comply with the Ontario Weed Control Act, which requires all landowners to control noxious weeds. Pressure for successful weed control is greatest in cropland areas where there is danger of reduced crop production, and in urban areas where allergies are a great concern.

There is room for change in public and Ministry attitudes with respect to weeds and the intensity of weed control required. In its attempt to reduce the extent of 2,4-D spraying to control weeds in park areas, the National Capital Commission (NCC) has acknowledged that NCC staff and the public will have to accept a decrease in turf quality [9]. There are parallels with highway right-of-way management. There may be extensive areas which could be sprayed less frequently. For example, in rural areas where highway rights-of-way are not adjacent to cropland, weed spraying frequency might be relaxed. Similarly, there are extensive areas of rights-of-way in urban settings which back onto industrial and other non-residential land. These areas could be allowed to naturalize. In recent years, naturalization of urban green space, including ravines, river valleys and parkland, is being practised by more municipalities.

Other responses to the public's concern about sprays have included the use of application techniques which localize the application of the chemical, e.g. wick applicators and spot applications in sensitive locations. The Ministry has been using these techniques for 10 years.

Ministry staff co-operate on an informal basis with landowners who do not want the right-of-way adjacent to their property sprayed. In those cases, the landowner might agree to assume responsibility for weed control.

Mechanical brush control may be possible but it is more labour intensive and is very expensive. Bark injection of brush control chemicals is another option, but this technique is also very labour intensive. Deferred cutting of brush can only be used with care as future control costs may be significant.

The feasibility of establishing wildflower plants along Ontario's highways has also been of interest to certain groups.

Integrated weed management, which consists of a program of different management components, may

4/ Policy Options

4.1/ The Challenge

Policy options can be formulated on the basis of a number of considerations. Improvement to current programs could be reflected in policy recommendations and emerging changes in technology and social expectations can play a role in shaping new policy.

This review has identified a number of challenges faced by the Ministry highway vegetation management program. These challenges are listed as background to identification of policy options.

Challenges include the following:

- continuation of limits on resources for vegetation management, along with continued inflation;
- sophisticated questions being asked and technical information being sought by the public;
- in some Districts, new construction is increasing the area of right-of-way to be managed;
- changes in vegetation management programs on the part of other agencies;
- demands on staff requiring increased levels of expertise and training;
- stress on vegetation caused by environmental conditions, e.g. road salt use, changing climate, acid precipitation, and air pollutants such as ozone.

The present review has also identified a number of specific issues which should be considered when formulating policy options. These issues include the following:

- the overall philosophy which guides the Ministry's vegetation management program:
 - (a) will the programs be designed to meet basic and historic program needs, or
 - (b) will new objectives be set which respond to public goals and concerns, emerging opportunities and new methods and technology;
- the Ministry's vegetation management program may be judged relative to programs implemented by other agencies;
- there is a need to address public and staff concerns about the use of pesticides;

- there is a need to determine from a highway safety and maintenance cost perspective whether natural regeneration areas will be a future problem;
- the recognition that staff training and technical support will play a critical role in the ability to meet current and future challenges;
- there is a need to focus research and development activities on studies and services which will facilitate delivery of the programs arising from selected policy options.

4.2/ Description of Options

Following a review of current vegetation management practices and the challenges and issues facing the Ministry, a series of policy options were developed. Five policy options were identified:

- A To optimize pesticide use;*
- B To design, construct and manage for long-term optimization of maintenance;*
- C To manage the rights-of-way to yield a product;*
- D To improve aesthetic quality of the rights-of-way; and*
- E To develop a new approach to dealing with the public.*

Tables 1 through 5 describe key components of these policy options. These descriptive tables indicate candidate programs which would be required to implement each policy option. The candidate projects which contribute to the programs and their implications are also described.

Candidate projects from certain policy options may be mutually supportive of other policy options. In other cases, they may create conditions which are at odds with other policy options.

Some of the options, programs and projects involve minor modifications or changes in emphasis to existing programs. Other programs and projects would involve a departure from current approaches and, thus, may not be considered feasible if assessed against past perspectives.

These programs and projects are suggested with the recognition that currently emerging perspectives

may be indicators of future standards. For example, as human population density increases, the pressure to use land in southern Ontario for productive purposes may increase. In the future, road rights-of-way may be viewed as a land base which should be managed to produce a product for revenue.

Also, with the heightened concern about tree cover and its role in mediating the greenhouse effect, there may be suggestions that extensive tree plantings occur on most public lands which are not used for active recreation. Another recent example of public concern creating change is the moratorium on chemical spraying in public school yards in Wellington County.

4.3/ Benefit-Cost Analysis

Before determining which of the policy options should be recommended, a benefit-cost (B-C) analysis was prepared. Appendix A contains the details of the B-C analysis. The purpose of the B-C analysis was to evaluate the economic and environmental costs and benefits in a greater level of detail than is contained in the implication sections of Tables 1-5.

Current quantitative information on costs is difficult to obtain for many program components. Tables in Appendix A describe most costs and benefits in a qualitative or comparative manner.

Conclusions from the B-C analysis are summarized here, as they play a key role in reaching conclusions about the recommended policy options.

Conclusions from the benefit-cost analysis are as follows:

- in recent years the Ministry has spent approximately \$2,000,000 on mowing, \$1,000,000 on weed spraying, and \$650,000 on brush control annually;
- for weed and brush control, chemical spraying is less expensive than mechanical methods;
- natural regeneration generally reduces vegetation management costs in the short term; at sites where brush control becomes a problem, long-term costs may be considerable;
- in some jurisdictions, for example Missouri, public assistance in managing highway rights-of-way has saved money;
- where public expectations regarding grass height and weed control can be reduced, considerable savings in vegetation management costs can be realized.

Table 1/ Candidate Programs, Candidate Projects and Implications of Policy Option A: To Optimize Pesticide Use

Candidate Programs	Candidate Projects	Implications
1. Reduce use of pesticides (e.g. 2,4-D)	• must identify substitute herbicides, combinations • replace with cultural management • public, weed inspectors, Ministry staff change expectations - tolerate small areas of weeds in non-sensitive locations • optimize effectiveness of current spraying to reduce future requirements for pesticide use • enter into "agreements" with adjacent landowners - they take over weed control responsibility	• need to monitor availability of new herbicides • more costly, requires staff training • requires education, change in attitude, less manicured appearance • inventory R.O.W. and adjacent land use • careful monitoring and possible changes in current methods • staff training, record keeping, monitoring requirements; safety and liability implications of public on rights-of-way; reduced control by Ministry
2. Develop and use integrated pest management systems	• develop a management system using certain herbicides, cultural management and co-operation from stake holders • research such options as biological control, allelopathy • increase use of landscape materials which out-compete weeds • increase use of technology which minimizes weed growth, maximizes survival of planted material e.g. plastics, mulch • increase maintenance operations which maximize survival of planted material e.g. watering, fertilization of cover plantings	• requires research, transfer of technology and training of District staff • requires research, transfer of technology and training of District staff • initially increased landscaping costs, decreased spraying costs in future • increased landscaping and maintenance costs, reduced spraying costs in future • increased maintenance costs, reduced future spraying costs
3. Optimize existing maintenance program to reduce weed growth	• review timing and height of mowing - avoid stressing grass by cutting during dry periods or scalping • provide adequate resources for maintenance of planted material	• may reduce mowing costs and weed control costs • increased maintenance costs, reduced future weed control costs
4. Prepare information for distribution	• response to public inquiries - safety, etc. • information to Ministry staff on use of sprays and their effects	• costs of preparation and public liaison • costs of preparation, training

Table 2/ Candidate Programs, Candidate Projects and Implications of Policy Option B: To Design, Construct and Manage for Long-term Optimization of Maintenance

Candidate Programs	Candidate Projects	Implications
1. Increase current planting of low maintenance species to reduce future need for mowing and spraying	• select species, and planting and maintenance regimes for extensive low maintenance plantings	• research and training regarding techniques • planting costs will increase in short term
2. Increase survival of current and past plantings	• careful matching of plant material to site conditions, e.g. soils, aspect, slope • water and fertilizer when required	• more care spent in selecting plant material • more time and materials spent on maintaining plantings
3. Expand area of natural regeneration	• further reduce extent of mowing • plant native species as a source for natural regeneration, maintain maturing natural regeneration areas	• reduced mowing cost, may increase weed control costs in the short term • increase planting costs • safety, drainage, snow implications as natural regeneration expands • research and train staff regarding maintenance of natural regeneration areas

Table 3/ Candidate Programs, Candidate Projects and Implications of Policy Option C: To Manage the Rights-of-Way to Yield a Product

Candidate Programs	Candidate Projects	Implications
1. Produce agricultural products	• grow cash crops along rights-of way of uncontrolled access highways • grow forage crops • tether grazing animals • graze sheep • plant vegetation species of value to honey bees	• safety and liability implications • reduced mowing and pesticide costs • extreme care in pesticide use near "bee habitat"
2. Produce forestry products	• grow hybrid poplar • grow valuable hardwood species	• safety and maintenance implications due to black ice, snow build-up, and shadows on the road surface • planting and maintenance costs • revenue generated
3. Produce wildlife	• develop habitat for certain game or fur species	• safety concerns related to wildlife near the roadway and humans harvesting (trapping) wildlife on the rights-of-way
4. Produce wildflower hay	• test planting and harvesting methods	• research and test techniques, train staff • may require new equipment • would support program to improve aesthetics of highway rights-of-way

Table 4/ Candidate Programs, Candidate Projects and Implications of Policy Option D: To Improve Aesthetic Quality of the Rights-of-way

Candidate Programs	Candidate Projects	Implications
1. Establishment of flowering species	• plant wildflower seed mix • plant bulbs, roots, cuttings • introduce wild asters and goldenrods in appropriate locations	• need to determine sites and species suitable for wildflower seedings • need to determine techniques suitable for Ontario conditions • may require maintenance to support sustained growth, e.g. reseed • weed control problems • research into use of methods in Ontario • train District staff • maintenance requirements • can produce masses of colour • allelopathy will assist in reducing competition and weeds • would need to research methods of establishing these plants • would reduce mowing and pesticide application costs
2. Increase visual diversity	• increase the mix of coniferous and deciduous plantings • increase use of mixed plantings of species of different heights and shapes	• initial costs of plant material • if planted area is increased, mowing costs will decline in the long-term • may reduce mowing requirements
3. Increase seasonal visual appeal of rights-of-way	• increase planting of plant species with bright autumn colours • increase planting of plant species which have bright fruit in the winter, e.g. highbush cranberry, mountain ash	• availability of desired plant material • suitability of soils and other conditions may limit where this approach can be implemented

Table 5/ Candidate Programs, Candidate Projects and Implications of Policy Option E: To Develop a New Approach to Dealing with the Public

Candidate Programs	Candidate Projects	Implications
1. Publicize past initiatives	• education re: reduction of mowing associated with natural regeneration	• staff time to develop information package and disseminate information
2. Organize new initiatives	• "Adopt a Highway" scheme • education re: pesticide use • contribution to sustainable development	• project administrative costs • loss of control, more supervision time • staff time and expertise to prepare information and disseminate information • training of District staff in public relations procedures • maximize environmental quality along rights-of-way
3. Involve public in roadside vegetation management	• public donate and/or plant trees, shrubs, flowers • public water and maintain trees and shrubs • public control weeds • public culture and harvest of products along rights-of-way	• public safety concerns, requirements for training/supervision • decrease need for mowing • increased number and survival of trees and shrubs • decrease need for weed control by the Ministry, may be able to depend more on mechanical control of weeds • safety and liability concerns • administrative costs, monitoring requirement

5 / Recommended Policies

5.1/ Description of Recommended Policies

A review of the policy options contained in Tables 1-5, the benefit-cost analysis contained in Appendix A and comments by Ministry staff on the policy options has led to the following policy recommendations.

As noted earlier, there is a basic philosophical issue to be addressed. Given the current social environment it may be possible to garner adequate financial support for policies which recognize the opportunities to use highway rights-of-way to demonstrate sustainable development. Components which would contribute to a sustainable development management program would include: reducing erosion, minimizing pesticide input into the environment, making efficient use of fossil fuels (e.g. truck and tractor use), maximizing use of low maintenance vegetation and maximizing food and cover for small species of wildlife which do not pose a hazard to vehicles.

Highway rights-of-way are highly visible to large numbers of people and they traverse a range of land use types. The alternative philosophical approach is to continue with the historic view that vegetation on rights-of-way is a costly problem to be controlled.

It is recommended that the Ministry adopt a new philosophy with respect to management of vegetation on highway rights-of-way. Assistance from the public might aid implementation. The public could assist in a number of ways: philosophical support for the new management approach, volunteer labour, and funds for planting materials. Under this scenario, the candidate program which would involve the public in roadside vegetation management would be appropriate.

Co-operative management agreements could be prepared for certain types of projects in locations where safety and liability risks are minimal. Although there would be administrative costs, the public goodwill and improved public understanding of the challenges faced by vegetation managers would be significant benefits. If the public could assist in mechanical control of weeds, the need for pesticide application in specific locations might be eliminated.

Public education about vegetation management practices is a logical addition to co-operative management projects. Efforts put into moderating public expectations regarding grass height and

treatment of minor weed infestations would reduce mowing and spraying costs and would improve environmental quality. The NCC has found that with education the public are willing to accept a naturalized landscape near their residences.

Wildflower plantings is an example of a program that could be labour intensive and would benefit from co-operative efforts with public interest groups. A separate technical study of co-operative management experiments in other jurisdictions and opportunities for Ontario has been prepared [17].

It is recommended that all of the candidate programs outlined in the policy option to optimize pesticide use (policy option A) be implemented. Program components include the following recommendations: reduce use of pesticides, develop and use integrated pest management systems, optimize existing maintenance programs to reduce weed growth and, prepare information on pesticide use along highways.

The recommendation to develop an integrated pest management system is already being acted on by the Ministry. Research into integrated weed management is being conducted in 1990.

When preparing information on pesticide use it will be necessary to account for the different needs in northern and southern Ontario. In northern Ontario it will be important to concentrate on bush control herbicides, whereas in southern Ontario the focus should be on herbaceous weed control.

The candidate programs within the policy option to design, construct and manage for long-term optimization of maintenance (policy option B) are also recommended for implementation. These programs include the following: increase current planting of low maintenance species, increase survival of current and past plantings, and expand area of natural regeneration.

These programs apply to southern Ontario where planting and tending turf, shrubs and trees involve considerable expense. Replacement of turf, which requires mowing and weed control, with ground covers and shrub plantings may save money in the long term. Added effort to water and fertilize expensive tree and shrub plantings would ensure that the capital investment is not lost.

There are still many slopes being mowed which could be allowed to naturalize. Although this requires a change in attitude regarding acceptable right-of-way appearance, naturalized slopes will

reduce mowing costs and diversify the ecology of the rights-of-way.

Management of the rights-of-way to yield a product (policy option C) is most practical in specific settings. There may be merit in pursuing some arrangement to allow farmers in southwestern Ontario to farm unfenced portions of rights-of-way along uncontrolled access highways. This arrangement reduces mowing and weed control costs and facilitates productive use of the land.

Planting of trees for forestry production may be viewed more favourably in the future. Currently, concerns about safety of the motoring public and safety of those tending and harvesting the trees are viewed as outweighing potential benefits of forestry on the rights-of-way.

Improving the aesthetics of the rights-of-way can be accomplished through a number of the preceding policy options, for example, when choosing plant material and in co-operative programs with the public. Initiatives to plant flowering species and shrubs to attract wildlife could increase the visual and ecological diversity of highway rights-of-way. The candidate programs to improve the aesthetic quality of the rights-of-way (policy option D) should be considered when implementing any changes to highway vegetation management in Ontario.

Establishment of flowering species would improve the visual appeal of highway rights-of-way. There are currently extensive areas of aster and goldenrod along highways in southern Ontario. In Michigan, several species of aster and goldenrod are considered to be wildflowers and are used along roadsides [26]. Current research by the Ministry into wildflowers is being expanded into field trials.

It is recommended that the Ministry develop a new approach to dealing with the public (policy option E). In particular, co-operative management of specific types of highway rights-of-way is recommended. More details on the merits of this recommendation appear in Stephenson [17]. As part of a co-operative management program, the public could be made aware of new and past initiatives which the Ministry has taken.

Co-operative management projects provide the opportunity to introduce more aesthetically appealing vegetation treatments and to replace chemical control of weeds with manual or mechanical techniques. Low maintenance plantings could also be installed as part of certain co-operative management projects.

6/ Recommended Research Plan

A research plan was prepared outlining and prioritizing research needs. The needs were formulated based on the following considerations:

- research which would yield information necessary to establish the feasibility of applying specific techniques in Ontario--this research would avoid costly expenditures on untested concepts;
- research which would improve application of proven techniques or technology;
- research which would be of value in training Ministry staff, e.g. demonstration plots;
- professional services which would produce information or facilitate training or implementation of new programs.

The priority assigned to the research needs listed in the recommended research plan was based on a consideration of:

- the urgency of the need,
- the logical order of policy option implementation,
- the recognition that current funding levels do not allow all of the research needs to be funded immediately.

Table 6 presents the recommended research plan. Over the next few years, additional research issues will emerge. Once some of the tasks listed are undertaken, follow-up research may be required.

Some of the research could be done in co-operation with special interest groups, e.g., wildflower plots. Demonstration plots would be most effective if District staff were directly involved and could provide their perspective on benefits and costs.

Table 6/ Recommended Highway Vegetation Management Research Needs

Research Need	Priority
a. Research the opportunities for using integrated pest management approaches in managing Ontario's highway rights-of-way. Identify components of such an integrated pest management approach and how these would be implemented.	1
b. Research and organize logistics for pilot projects(s) involving co-operative management of rights-of-way with the public. Examples could include row crop farming in southwestern Ontario and flower plantings in high profile rural areas.	2
c. An evaluation of low maintenance species and methods of planting for use in Ontario. Include research on wildflowers and allelopathic taxa e.g. aster, goldenrod, ferns for Ontario roadsides.	2
d. Research and map areas where mowing can be reduced further or eliminated in southern Ontario. Justify the recommendations and review with the affected Districts. This will produce immediate and direct cost savings.	2
e. Research alternatives to the standard Ministry seed mix. Determine whether cultivars are a solution. Develop a mix which competes with weeds and has a low growth form (requires less mowing).	3
f. Research and write an information package on spraying; put the need into perspective relative to integrated pest management approaches. Provide to District staff and use to respond to public concerns.	3
g. Research the natural regeneration plots studied in 1975-1981 and others. Determine whether there is an emerging long-term maintenance problem associated with natural regeneration plots, i.e. are they encroaching on the road margin.	4
h. Research the problem of planted tree and shrub mortality. Provide specific guidance regarding maintenance tasks and scheduling to increase survival of planted material.	5

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NOTE: Additional references are listed on page 39 in Appendix A.

Appendix A/ Benefit-Cost Analysis of Vegetation Management Policy Options and Programs

To effectively evaluate the various vegetation management options, programs, and projects presented in the main report, an assessment of benefits relative to costs is required. An investigation of predicted costs and benefits can be compared to current Ministry practices and the experiences or trends reported from other jurisdictions.

A-1/ Methods

Data for this benefit-cost (B-C) analysis were obtained from a number of sources including: Ministry Operations Reports for 1987/88 and 1988/89 (computer printouts), as well as published literature from other jurisdictions, especially in the United States.

The literature contains extensive information on modifications to mowing practices and the impact of these changes on total budgets, as well as the increased use of chemicals and chemical mixtures to decrease the cost of vegetation management systems. There is a limited amount of actual benefit-cost data available that deals with biological or cultural management. The information in the literature deals with wide-ranging locations with differing vegetation management needs and constraints over several years. The literature generally describes trends over time or pair-wise comparisons between mowing and spraying. The bulk of the literature documents the shift in emphasis from mechanical to chemical vegetation control. Most available published information contains qualitative assessments of cost-effectiveness and/or projected overall cost savings.

This analysis attempts to evaluate program benefits relative to costs using available data in conjunction with best estimates for missing data. Attempts are also made to relate actual Ministry operations data to proposed program modifications and predicted financial implications. A number of the costs and benefits cannot readily be expressed directly in financial terms. Due to the limitations of the available data this B-C analysis is not a rigorous analysis, but it could be refined when more detailed relevant data becomes available.

A-2/ Findings

Summary Tables

Tables 7 to 21 describe the costs and benefits associated with the policy options and programs outlined in the body of the report. A description of the anticipated costs and benefits, as well as comments regarding predicted financial implications of the proposed program are included in these tables.

Many of the costs and benefits are difficult to quantify. The "comments" section of the tables includes general qualitative statements with supportive literature references where available.

Examples of current expenditures for various vegetation management activities carried out by the Ministry are presented in Tables 22 to 27. These tables yield information on recent average unit cost to complete certain tasks. They also indicate the relative levels of annual expenditure on key vegetation management program components. Approximately \$2,000,000 is spent on mowing, \$1,000,000 is spent on weed spraying and \$650,000 is used to control brush. Maintenance of plantings requires approximately \$500,000 on an annual basis, in addition to capital expenditures on seeding, mulching and tree and shrub planting.

A-3/ Review of Benefits and Costs Associated with Policy Options

Policy Option A: Optimization of Pesticide Use

The optimization of pesticide use includes: an overall reduction in pesticide use; shifts to the use of new chemicals or combinations of chemicals; integrated pest management; and the optimization of other vegetation management techniques, for example, improved mowing practices.

For weed control, chemical spraying is less expensive than mowing (see Tables 22 and 23). Mowing, however, yields turf height control, as well as a measure of brush and weed control.

The use of chemical sprays to control brush accounts for a large portion of the annual budget for spraying (Table 24). This expenditure is directed towards a relatively small area, resulting in a large unit cost for chemical brush control. The cost is much less when considered on an annual basis, since treatment cycles range from three to six years.

The annual expenditure for brush cutting is less than that for chemical control, but no cost per area data was available for mechanical brush control to make an effective cost comparison with brush spraying. It is generally recognized that mechanical and manual brush control is several times more expensive than chemical control.

An overall decrease in pesticide use may not have direct cost savings, especially if the same level of control is required. Other techniques for vegetation control, including mechanical and cultural systems, are generally more expensive. Environmental and social benefits may result from a decrease in pesticide use.

Policy Option B: Design, Construct and Manage for Long-Term Optimization of Maintenance

The long-term optimization of right-of-way maintenance consists of programs to increase the area covered by low maintenance plantings and natural regeneration, and includes projects aimed at increasing the survival of these plantings. An increase in these areas will require some initial expenditures to establish effective plantings as well as maintenance activities to ensure the continued survival of the plantings. An overall decrease in the areas requiring spraying or mowing, in conjunction with reduction in erosion control and replanting costs, will result in a cost savings.

Ministry data indicate that approximately \$450,000 annually is directed towards maintenance of trees, shrubs, and seedlings (Table 26). Table 27 indicates capital expenditures on tree and shrub planting during recent years. An increase in effort during the planting and short-term maintenance of vegetation will result in an overall decrease in costs in the long-term due to decreased replacement and corrective maintenance.

Policy Option C: Managing Rights-of-way to Yield a Product

Using the rights-of-way to produce a usable product can have financial implications in two ways. First, the area requiring spraying or mowing will decrease, and second, the sale of the product may provide some benefit.

Based on the projected costs associated with the equipment, labour, and expertise required, it would be cost prohibitive for Ministry staff to be directly involved in harvesting products from the right-of-way. However, the use of public interest groups or individual landowners (especially farmers) would appear to make these programs feasible. The safety and liability concerns regarding public involvement, as well as those associated with encouraging wildlife are difficult to quantify. It would appear that many of the potential costs could be kept to a

minimum with careful site selection, supervision, and project management.

Policy Option D: Improve Aesthetics of the Right-of-way

A number of approaches to highway right-of-way management can improve the aesthetics or visual appeal of these areas. Many of the costs and benefits associated with these programs are similar to those realised by increasing survivorship of plantings. An additional investment in wise selection of species including wildflower mixes, and mixes of various woody species can have long-term benefits in terms of tourism, as well as potential decreases in mowing. These approaches may require species that are initially more expensive and may require care in matching species and sites.

The Ministry often uses a grass mixture to revegetate portions of the right-of-way. Tables 25 and 27 indicate that the cost per hectare of grass seeding is in the \$2700-3000 range. The use of wildflowers may be comparable. If wildflower areas had to be reseeded, this option would not be attractive.

Policy Option E: New Approaches to Dealing with the Public

A number of jurisdictions have used co-operative projects with public or private organizations to decrease planting and maintenance costs through reduced labour costs. The involvement of the public, as well as public education will produce some social benefits that are less easy to quantify, for example, public awareness and support.

A number of labour-intensive management approaches (e.g. right-of-way farming) can be more cost-effective if the public is involved. Again, the potential costs of safety and liability must be a consideration.

A-4/ Conclusions

This benefit-cost analysis does not suggest any quick-fix solutions or clear cost savings for right-of-way vegetation management. Any new management initiatives, and most ongoing programs, will ultimately benefit from research, experimentation, education and training of staff. Other factors, such as social or environmental benefits, may drive policy decisions at the expense of increased expenditures. An example of this is the decreased use of pesticides by the National Capital Commission [9].

A consistent finding appears to be that long-term financial, aesthetic, or environmental benefits may be realized by shifting emphasis from reactive maintenance and management (e.g. brush spraying, cutting, tree removal) to proactive vegetation management (e.g. planting and establishment of low-

maintenance vegetation). A change in expectations with regard to maintenance quality standards may provide sufficient latitude in management to enable shifts from the standard maintenance approaches (i.e. weed control, mowing, brush control) to activities or projects that would result in long-term decreases in maintenance requirements (i.e. low maintenance plantings, emphasis on post-planting maintenance of plantings, natural regeneration). This may be possible by redirecting existing funding.

Table 7/ Costs/Benefits of Policy Option A: Candidate Program 1

Policy Option A: To Optimize Pesticide Use Candidate Program 1: Reduce Use of Pesticides (e.g. 2,4-D)		
Costs	Description of Costs	Comments
1. Education and Training	costs associated with educating and training Ministry staff in new pesticides, combinations, timing of application, new technology	all new initiatives will involve costs associated with training and education
2. Research and Experimentation	evaluation of new pesticides, combinations, timing of application, new techniques (e.g. use of adjuvants, plant growth regulators)	costs will vary depending on new technology, many private companies are experimenting in this field and the costs may not be incurred by the Ministry
3. New Technology	costs associated with acquisition of new equipment (e.g. spray nozzles, modifications to existing equipment) and new chemicals	costs for purchasing new equipment (sprayers, etc.) may increase, will vary with technique
4. Information Preparation and Dissemination	costs associated with educating public, weed inspectors, Ministry staff to change expectations and tolerate small areas of weeds	costs for preparing and disseminating information will increase
5. Introduction of Other Vegetation Management Techniques	costs associated with continuing the quality of vegetation management with substitute techniques (e.g. mowing, plantings, etc.)	decreased use of pesticides may result in increased costs of other techniques (e.g. mowing) [1,8,16,49,50]
Benefits	Description of Benefits	Comments
1. Labour and Equipment	labour and equipment costs associated with more efficient use of pesticides	- labour costs associated with chemical applications may decrease as result of overall decrease in amount of spraying [36] - may be offset by increased labour required for other vegetation management techniques
2. Chemicals	costs of pesticides	- if there is an overall reduction in application of chemicals, a reduction in costs of chemicals is expected [37] - increased use of adjuvants will decrease overall chemical costs [10,46] - increased use of chemical mixtures will decrease overall chemical costs [45,46] - improved timing of chemical applications will decrease costs [43,46] - multiple applications of pesticides will be more costly than a single application, but more economic in the long-term [29]
3. Public Awareness	value associated with more informed and co-operative public	increased education in conjunction with reduced pesticide use will produce a more informed and co-operative public
4. Environmental Quality	benefits associated with improved environmental quality	reduced use of pesticides results in improved environmental quality [8,49]
5. Liability for Spray Accidents	liability costs incurred due to accidental spray applications	increased use of improved techniques results in decreased liability costs [12,24]

Table 8/ Costs/Benefits of Policy Option A: Candidate Program 2

Policy Option A: To Optimize Pesticide Use Candidate Program 2: Develop and Use Integrated Pest Management Systems		
Costs	Description of Costs	Comments
1. Research and Experimentation	evaluation of combinations of pesticides, planting (e.g. species that out-compete weeds), biological control agents (e.g. allelopally), cultural techniques	costs will vary depending on components and complexity of integrated pest management systems
2. Education and Training	costs associated with educating and training Ministry staff in use of integrated pest management systems	costs will vary depending on components and complexity of integrated pest management systems
3. New Technology	costs associated with upgrading or modifying equipment	requirements and costs for new technology will vary depending on components of pest management systems
4. Plantings and Maintenance of Planted Material	costs associated with establishing and maintaining plantings (including watering, fertilization)	- costs will increase due to increased training, labour and materials - see Policy Option B: Candidate Programs 1 and 2 for potential costs
5. Use of Mulches	costs of providing mulches (e.g. plastic coverings) to decrease weed invasion or growth	material and installation (labour) costs will be relatively high
6. Co-operative Management	involvement of public in certain aspects of integrated pest management (e.g. plantings or maintenance)	- costs of supervision, administration for Ministry staff will increase - see Policy Option E: Candidate Program 3 for potential costs
Benefits	Description of Benefits	Comments
1. Spraying and Mowing Costs	costs associated with spraying and mowing	- costs for spraying and mowing will decrease due to decreased weed invasion - costs for spraying will decrease in the future due to improved spray efficiency [36] - combined mechanical and chemical vegetation management system is most economical [54,3]
2. Plantings and Maintenance	costs for installing and maintaining plantings	in the long term, decreased pests and increased survival of plantings will reduce the labour required to plant and maintain vegetation [25]
3. Environmental Quality	associated with improved environmental quality	- reduction in use of pesticides will result in improved environmental quality [49] - less pesticide residue in the environment

Table 9/ Costs/Benefits of Policy Option A: Candidate Program 3

Policy Option A: To Optimize Pesticide Use Candidate Program 3: Optimize Existing Maintenance Program to Reduce Weed Growth		
Costs	Description of Costs	Comments
1. Education and Training	• costs of educating and training Ministry staff in new mowing practices	• all new initiatives will involve costs associated with training and education
2. Inspections	• costs for inspecting and monitoring right-of-way to identify mowing needs	• labour costs for monitoring, determining optimum time, height, and location of mowing, will increase
3. Modification to Mowers	• costs associated with purchasing new mowing attachments or equipment or modifying existing equipment (e.g. increased mowing height)	• costs will vary depending on type of modifications required; these costs will most likely be very low if existing equipment can be used
4. Public Education	• costs associated with educating public to change expectations and tolerate small areas of weeds, or taller grass	• costs for preparing and disseminating information will increase
5. Maintaining Planted Material	• costs for providing adequate resources for maintaining planted material	• see Policy Option B: Candidate Program 2
Benefits	Description of Benefits	Comments
1. Health of Vegetation	• value of healthy turf (not stressed by cutting during dry periods or scalping)	• over-seeding costs decrease • reduced invasion by weed species cuts costs of chemical or mechanical weed control [10] • turf vigour is reduced if grass is cut too short [20] • decreased labour and plant material costs associated with removal and/or replanting areas
2. Aesthetics	• benefits associated with more vigorous roadside vegetation	• may have positive impacts on tourism • decrease public complaints with respect to dead turf and/or exposed soil
3. Erosion	• benefits associated with controlling and reducing erosion	• scalping of turf causes increased erosion [20] • costs of controlling and repairing erosion will decrease [35]
4. Litter	• costs associated with litter pick-up	• some modifications to mowing practices will result in areas of higher grasses, or natural regeneration; this will decrease the visibility of litter and decrease cost of litter pick-up
5. Spraying Costs	• costs of using chemical vegetation management	• modified mowing practices may decrease spray costs by decreasing weed invasion • maintaining planted material will decrease the area requiring spraying
6. Mowing Costs	• overall labour and machine costs	• decreased frequency and area of mowing will decrease overall mowing costs • increased mowing height will decrease total mowing effort (10) • unit costs of mowing (cost/ha) have increased over years [12,17,42] • designation of areas that require differing intensities of mowing decreased overall mowing costs [18,20,22,51,56]
7. Grass Seeding	• costs of reseeding or overseeding grassed areas	• increased health of turf will decrease requirement and seed costs associated with reseeding or overseeding areas • decreased scalping will decrease costs for reseeding

Table 10/ Costs/Benefits of Policy Option B: Candidate Program 1

Policy Option B: To Design, Construct, and Manage for Long Term Optimization of Maintenance Candidate Program 1: Increase Low Maintenance Plantings		
Costs	Description of Costs	Comments
A. Site and Plant Material Selection		
1. Research	• evaluation of site and species characteristics and suitability (including pilot projects)	• variable costs associated with research, but generally a one time only cost • will vary directly with variety of site types researched and range of species
2. Site Selection	• identification, mapping, and field marking of appropriate planting sites	• will vary with variety of site types and range of species to be planted • will vary depending on number of sites, size of sites - labour cost
B. Planting and Establishment		
1. Education and Training	• training of Ministry staff regarding planting and maintenance techniques	• offered on an "as-needed" basis, frequency and costs will decrease as experience and knowledge increases at District or crew level
2. Plant Material Purchase	• obtaining sufficient seeds and stock for establishment	• initially expensive and difficult to secure, but cheaper than wildflowers [25] • will become less expensive and easier to purchase propagules over time [25] • seeds cheaper than seedlings [25]
3. Site Preparation	• preparing site for planting (including removal of existing vegetation)	• least expensive on construction sites [25] • costs of plowing, spraying, disking currently vegetated sites very high [25]
4. Planting	• establishment of propagules/planting stock	• transplants more expensive than seeding [25] • drill seeding more expensive than broadcast or hydro-seeding [25]
C. Maintenance		
1. Education and Training	• see Planting and Establishment	• see Planting and Establishment
2. Signage	• permanent field marking of low maintenance plots	• will vary depending on type of signs used, long-term benefits because signage decreases accidental mowing or spraying of site
3. General	• post-planting activities aimed at ensuring survival and visual appeal of plantings	• the more expense incurred in site preparation and planting phases, the lower the maintenance costs [25] • transplant survival is greater than from seeds, less reseeded required [25]
Benefits	Description of Benefits	Comments
1. Erosion Costs	• costs associated with controlling erosion on rights-of-way	• decreased costs associated with erosion with use of mulches during planting [17] • decreased costs associated with erosion repair with use of crown vetch (annual savings > \$300,000) [61]
2. Litter Costs	• costs associated with litter pick-up along rights-of-way	• for low maintenance plantings that result in a dense growth of road side vegetation the visibility of litter decreases and this results in a decrease in litter pick-up costs [18]
3. Spraying and Mowing Costs	• costs associated with standard chemical and mechanical based vegetation management systems	• decrease in area requiring mowing or spraying • decreased mowing resulting from use of crown vetch has (on an unspecified area in Massachusetts) resulted in savings > \$300,000/yr. [61] • use of tree and shrub plantings with wood chips over 500 miles of right-of-way cut mowing costs by 25% in 1977 [61]

Table 11/ Costs/Benefits of Policy Option B: Candidate Program 2

Policy Option B: To Design, Construct, and Manage for Long Term Optimization of Maintenance Candidate Program 2: Increase Survival of Plantings		
Costs	Description of Costs	Comments
A. Planting and Establishment		
1. Education and Training	• training of Ministry staff regarding planting and maintenance techniques • evaluation and matching of site and species characteristics	• offered on an "as-needed" basis, frequency and costs will decrease as experience and knowledge becomes established at District level or crew level
2. Site Preparation and Planting	• preparing site and planting (including removal of existing vegetation)	• least expensive on construction sites [25] • more expense and effort put into proper site preparation and planting, decrease future costs for plantings • high labour costs required for proper establishment of shrub beds [56]
3. Stock Purchase	• costs of purchasing plant material	• can be expensive and difficult to obtain appropriate species, sizes, vigour [25]
B. Maintenance		
1. Education and Training	• see Planting and Establishment	• see Planting and Establishment
2. Planting Inspections	• costs associated with inspecting plantings to determine what maintenance is required	• labour costs for inspection will increase, education and training costs will also increase
3. Watering Plantings	• costs associated with ensuring plantings have adequate water, especially in times of drought	• labour costs for watering will increase, but this will vary depending on weather and site conditions
4. Fertilizing Plantings	• costs associated with supplying fertilizer to plantings when needed	• costs of fertilizer will increase • labour costs for fertilizing will increase
5. Removal of Competing Species	• costs associated with control or removal of unwanted plant species (including grasses or weeds) to decrease competition for nutrients, water, space	• may require use of selective herbicides and costs for chemicals and manpower will increase [59] • use of mulch around trees decreases weed competition [59] • mowing or other mechanical control measures may increase
6. Rodent Control	• costs associated with controlling rodent damage to plantings	• costs for rodenticides, chemical repellents, or physical stem protectants will increase • labour for installation or application of control measures will increase
Benefits	Description of Benefits	Comments
1. Removal of Dead Plant Material and Re-planting	• labour and material costs associated with removal and replacement of dead vegetation	• costs of site and species selection, site preparation, planting, and maintenance decrease costs of removing and replacing dead vegetation [25,40,59] • removal of brush and trees is more costly than maintenance [64]
2. Aesthetics	• value of providing aesthetically pleasing right-of-way	• increased survival will increase aesthetics and may be positive for tourism
3. Erosion	• costs associated with the control and repair of erosion	• increased survival of plantings will decrease erosion costs • use of fertilizers and mulches decreases erosion [57]

Table 12/ Costs/ Benefits of Policy Option B: Candidate Program 3

Policy Option B: To Design, Construct, and Manage for Long Term Optimization of Maintenance Candidate Program 3: Increase Area of Natural Regeneration		
Costs	Description of Costs	Comments
A. Site and Species Selection		
1. Experimentation and Research	identification of appropriate locations and appropriate plant species	- costs generally low - if seed source plants are to be researched then will incur costs; will vary depending on range of site conditions and range of plant species being researched
B. Planting and Establishment		
1. Unaided Natural Establishment	costs associated with natural establishment of plants with no active planting etc.	- no costs - no control over species which become established [25] - may require mowing, selective herbicide treatments, and over-seeding
2. Planting of Species as Seed or Propagule Source	costs associated with planting and establishing plants on right-of-way including species that regenerate vegetatively (e.g. sumac, high-bush cranberry, dogwoods)	- see Candidate Program 2 for costs associated with Education and Training and other maintenance requirements - generally these plantings will require less maintenance than landscape/horticultural plantings
3. Brush Control	costs associated with control of unwanted woody species on rights-of-way	- very expensive to control [16,43] - may outweigh benefits of natural regeneration in some cases [43]
C. Other		
1. Accidents	liability costs associated with accidents between vehicles and brush, ice formation on shaded section of highway	maintenance costs increase as unwanted brush establishes and matures [8,18,43]
2. Fire Damage	costs associated with fire damage and fire suppression on rights-of-way	costs increases as natural regeneration increases [18]
3. Drainage	costs associated with cleaning and/or repairing obstructed drainage courses (including any resulting erosion)	costs increases as natural regeneration increases [8,18]
4. Snow Removal	costs associated with snow removal on highways	costs may increase as natural regeneration increases and grows towards the shoulder, depends on setting, site conditions
Benefits	Description of Benefits	Comments
1. Mowing and Spraying	costs associated with standard chemical and/or mechanical vegetation management	- may increase in short-term if site preparation is required [25] - in long-term creates a decrease in area and costs of mowing and spraying for weeds [56] - establishment of unwanted brush species may be very costly to control and outweigh any benefits [43,52]
2. Litter	costs associated with litter pick-up along rights-of-way	as regeneration matures, litter is less apparent and costs for litter pick-up decrease [18]

Table 13/ Costs/Benefits of Policy Option C: Candidate Program 1

Policy Option C: To Manage the Rights-of-way to Yield a Product		
Candidate Program 1: Produce Agricultural Products		
I Staff Involved in the Actual Production of Agricultural Products		
Costs	Description of Costs	Comments
1. Education and Training	• training of Ministry staff regarding production of agricultural products	• potentially expensive but will decrease as experience and expertise becomes established at the District level
2. Crops	• experimentation and research into selection of appropriate sites and crop types (including pilot projects)	• considerable costs
a) Site and Crop Selection		
b) Operating Costs	• costs associated with operating cropland including new equipment, spraying, fertilizing, watering, harvesting	• cost prohibitive for the Ministry to become actively involved in
3. Livestock	• selection of appropriate sites and livestock (including pilot projects)	• considerable costs
a) Site Selection		
b) Operating Costs	• costs associated with operating livestock pasture including stock	• cost prohibitive for the Ministry to become actively involved in
c) Accidents	• costs associated with collisions between vehicles and livestock	• potentially high liability costs
4. Other	• costs associated with establishment of plant species attractive to honey bees	• see Policy Option D: Candidate Program 1
a) Honey Bee Plants		
Benefits	Description of Benefits	Comments
1. Mowing and Spraying Costs	• costs associated with chemical and mechanical vegetation management	• costs will decrease as area of right-of-way requiring spraying or mowing decreases • decrease may be outweighed by large costs involved in Ministry operating cropland and/or livestock
2. Agricultural Production	• value of agricultural products	• value will vary with intensity and type of agricultural operation, generally not sufficient to off-set costs
3. Aesthetics	• visual appeal of wildflower plantings for honey bees	• indirect benefits to local honey producers
II Public Involvement: Local Co-operators Use Rights-of-Way to Produce Agricultural Products		
Costs	Description of Costs	Comments
1. Education and Training	• costs associated with training Ministry staff, site selection	• will vary depending on type of project
2. Project Supervision, Administration	• costs associated in supervision of projects and public participants	• will vary depending on size and type of project (minimal for projects involving individual landowners maintaining areas adjacent to their own property)
3. Accidents	• costs associated with safety and liability with regard to accidents involving public	• generally kept to a minimum by supervision, training, and written waivers [25]
4. Operating Costs	• costs associated with operating cropland or livestock operations on right-of-way	• costs will not be incurred by Ministry; these are the responsibility of the farmer
Benefits	Description of Benefits	Comments
1. Public Awareness	• value of increased public awareness with respect to the Ministry program	• garners public support for future program initiatives
2. Labour	• impact on Ministry labour	• decrease in Ministry staff time spent mowing and spraying
3. Agricultural Products	• value of agricultural products	• use of right-of-way by adjacent farmers can increase total production from farm operation by actually harvesting products from right-of-way or using right-of-way for equipment movement, turning, etc.
4. Mowing, Spraying	• costs associated with chemical or mechanical vegetation management	• increase in area planted, in agriculture, or managed by local landowners - decreases area requiring mowing or spraying by the Ministry

Table 14/ Costs/Benefits of Policy Option C: Candidate Program 2

Policy Option C: To Manage the Rights-of-way to Yield a Product Candidate Program 2: Produce Forestry Products		
Costs	Description of Costs	Comments
A. Site and Plant Material Selection		
1. Experimentation and Research	• evaluation and matching of site and species characteristics (including pilot projects)	• will vary with range of site conditions and range of plant species being considered
B. Planting and Establishment		
1. Education and Training	• training of Ministry staff regarding planting and maintenance techniques	• offered on an "as-needed" basis, frequency and costs will decrease as experience and knowledge become established at District level or crew level
2. Site Preparation and Planting	• preparing site and planting (including removal of existing vegetation)	• may require spraying, mowing, plowing, discing • least expensive on construction sites [25] • more expense and effort put into proper site preparation and planting, decrease future maintenance costs • plantation more costly than allowing natural re-vegetation of trees [60]
3. Stock Purchase	• costs of purchasing plant material	• can be expensive and difficult to obtain appropriate species, sizes, vigour
C. Maintenance		
1. Signage	• permanent field marking of forestry plots	• initial expense off-set by long-term benefits by decreasing accidental mowing or spraying
2. General	• post-planting activities aimed at ensuring survival and good economical growth of planting	• high costs composed of monitoring and inspection, maintenance labour, watering, fertilizer
3. Brush Control	• costs associated with control of unwanted woody species on rights-of-way	• very expensive to control [16,43]
D. Other		
1. Accidents	• liability costs associated with accidents between vehicles and trees, ice formation on shaded section of highway	• costs increase as woody species establish and mature [8,18,43]
2. Fire Damage	• costs associated with fire damage and fire suppression on right-of-way	• costs increase as trees mature [18]
3. Snow Removal	• costs associated with snow removal on highways	• costs may increase as treed area increases, depends on setting and site
Benefits	Description of Benefits	Comments
1. Mowing and Spraying	• costs associated with standard chemical and/or mechanical vegetation management	• may increase in short-term if site preparation is required • in long-term, decrease in area and cost of mowing and spraying for weeds [56, 60] • establishment of unwanted brush species may be very costly to control and outweigh any benefits [43,52]
2. Litter	• costs associated with litter pick-up along rights-of-ways	• as regeneration matures litter is less apparent and costs for litter pick-up decreases [18]
3. Aesthetics	• value of providing aesthetically pleasing rights-of-way	• increase aesthetics and may be positive for tourism
4. Forestry Production	• value generated by sale of wood, re-constituted products (paper, particle board, fuel wood, Christmas trees)	• limited by area available for safely producing large caliper trees • greater return from plantation-style forestry compared to harvesting natural regeneration sites [60]

Table 15/ Costs/Benefits of Policy Option C: Candidate Program 3

Policy Option C: To Manage the Rights-of-way to Yield a Product Candidate Program 3: Produce Wildlife		
Costs	Description of Costs	Comments
A. Site and Species Selection		
1. Experimentation and Research	• identification of appropriate locations and appropriate species	• generally low • will vary depending on range of site conditions and range of plant species being considered
B. Planting and Establishment		
1. Un-aided Natural Establishment	• costs associated with natural establishment of wildlife	• no costs • no control over species [25]
2. Planting of Species for Wildlife Habitat or Food Sources	• costs associated with planting and establishing plants on rights-of-way	• see Policy Option B: Candidate Program 2 for costs associated with this approach (Education and Training, Site Preparation and Planting, Stock Purchase)
C. Maintenance		
1. Signage	• permanent field marking of plots	• initial expense off-set by long-term benefits by decreasing accidental mowing or spraying
2. Care of Seed Source Plantings	• costs associated with maintenance of species planted for wildlife	• see Policy Option B: Candidate Program 2 for costs associated with Education and Training and other maintenance requirements • generally these plantings will require less maintenance than landscape/horticultural plantings
D. Other		
1. Accidents	• liability costs associated with accidents between vehicles and wildlife on highway	• costs increase as woody habitat plantings encroach on highway [8,18,43]
2. Fire Damage	• costs associated with fire damage and fire suppression on rights-of-way	• costs increase as natural regeneration increases [18]
3. Drainage	• costs associated with cleaning and/or repairing obstructed drainage courses (including any resultant erosion)	• costs increases as natural regeneration increases [8,18]
4. Snow Removal	• costs associated with snow removal on highways	• costs may increase as wildlife habitat plantings increase
Benefits	Description of Benefits	Comments
1. Mowing and Spraying	• costs associated with standard chemical and/or mechanical vegetation management	• may increase in short-term if site preparation is required [25] • in long-term, decrease in area and cost of mowing and spraying for weeds [56] • establishment of un-wanted brush species may be very costly to control and outweigh any benefits [43,52]
2. Aesthetics	• visual appeal of wildlife sightings and wildlife plantings	• potential increase in tourism
3. Litter	• costs associated with litter pick-up along rights-of-way	• as shrubby habitat matures litter is less apparent and costs for litter pick-up decrease [18]
4. Wildlife Products	• value associated with harvesting of wildlife - related products	• will vary depending on wildlife species

Table 16/ Costs/Benefits of Policy Option C: Candidate Program 4

Policy Option C: To Manage the Rights-of-way to Yield a Product		
Candidate Program 4: Production of Wildflower Hay		
Costs	Description of Costs	Comments
A. Site and Plant Material Selection		
1. Experimentation and Research	• evaluation of site and species characteristics and suitability (including pilot projects)	• variable costs associated with research, but generally a one time only cost (at program start-up) • will vary directly with site conditions and range of species
2. Site Selection	• identification, mapping, and field marking of appropriate planting sites on District level	• see above, will vary depending on number of sites, area of sites
B. Planting and Establishment		
1. Education and Training	• training of Ministry staff regarding planting, maintenance and harvesting techniques	• offered on an "as-needed" basis, frequency and costs will decrease as experience and knowledge become established at District level or crew level
2. Plant Material Purchase	• obtaining sufficient seeds or propagules for establishment	• initially expensive and difficult to secure, more expensive than grass/legume mix [25] • will become less expensive and easier to produce propagules as wildflower hay project becomes established [25] • seeds cheaper than seedlings [25]
3. Site Preparation	• preparing site for planting (including removal of existing vegetation)	• least expensive on new, unvegetated sites [25] • costs of plowing, spraying, disking vegetated sites very high [25]
4. Planting	• establishment of propagules	• transplants more expensive than seeding [25] • drill seeding more expensive than broadcast or hydroseeding [25]
C. Maintenance		
1. Education and Training	• see Planting and Establishment	• see Planting and Establishment
2. Signage	• permanent field marking of wildflower plots	• will vary depending on type of signs used, long-term benefits by decreasing accidental mowing or spraying of site
3. General	• post-planting activities aimed at ensuring survival and visual appeal of plantings	• the more expense incurred in site preparation and planting phases, the lower the maintenance costs [25] • transplant survivorship is greater than seeds, less re-seeding required [25] • use of species with allelopathy (e.g. goldenrods or asters) may decrease maintenance costs [28]
D. Harvest		
1. Education and Training	• see Planting and Establishment	• see Planting and Establishment
2. New Equipment	• costs associated with obtaining specialized harvest equipment	• new equipment may need to be purchased, will be less expensive if modification to existing equipment can be used
3. Handling and Storage	• costs associated with storing, packaging, and transporting hay	• will vary depending on proposed use and location of hay
Benefits	Description of Benefits	Comments
1. Litter Costs	• costs associated with litter pick-up along rights-of-way	• a dense growth of roadside wildflowers decreases visibility of litter and results in decrease in litter pick-up costs [18]
2. Spraying and Mowing Costs	• costs associated with standard chemical and mechanical based vegetation management systems	• decrease in area requiring mowing or spraying [25,35] • costs associated with establishment and maintenance are quite high but savings can be realized when wildflowers are used on sections of rights-of-way requiring high level of maintenance [25]
3. Aesthetics	• value associated with improved visual appeal	• possible increase in tourism [41]
4. Seed Source	• value associated with production of wildflower hay	• decrease costs for seeds in future wildflower plantings

Table 17/ Costs/Benefits of Policy Option D: Candidate Program 1

Policy Option D: To Improve Aesthetic Quality of Rights-of-way Candidate Program 1: Establishment of Flowering Species		
Costs	Description of Costs	Comments
A. Site and Plant Material Selection		
1. Research	evaluation of site, individual species characteristics, species mixes and seeds versus bulbs or transplants (including pilot projects)	- variable costs associated with research, but generally a one time only cost (at program start-up) - will vary directly with site conditions and range of species
2. Site Selection	identification, mapping, and field marking of appropriate planting sites at District level	- will vary depending on number of sites, area of sites - will vary with site conditions and range of species
B. Planting and Establishment		
1. Education and Training	training of Ministry staff regarding planting and maintenance techniques	offered on an "as-needed" basis, frequency and costs will decrease as experience and knowledge become established at district level or crew level
2. Plant Material Purchase	obtaining sufficient seeds or propagules for establishment	depends on species: may be more expensive than grass/legume mix [25]
3. Site Preparation	preparing site for planting (including removal of existing vegetation)	- least expensive on construction sites [25] - costs of plowing, spraying, discing vegetated sites very high [25]
4. Planting	establishment of propagules	- transplants more expensive than seeding [25] - drill seeding more expensive than broadcast or hydroseeding [25] - erosion blankets or mulches may be required to prevent erosion while wildflowers establish [14] - costs to establish wildflowers per ha \$2500 to \$7500 (Michigan in 1985) [25]
C. Maintenance		
1. Education and Training	see Planting and Establishment	see Planting and Establishment
2. Signage	permanent field marking of wildflower plots	will vary depending on type of signs used, long-term benefits by decreasing accidental mowing or spraying of site
3. General	post-planting activities aimed at ensuring survival and visual appeal of planting	- the more expense incurred in site preparation and planting phases, the lower the maintenance costs [25] - transplant survival is greater than seeds, less re-seeding required [25] - use of species with allelopathy (e.g. golden rods or asters) may decrease maintenance costs [28]
Benefits	Description of Benefits	Comments
1. Erosion Costs	costs associated with controlling erosion on rights-of-way	established plantings will control erosion
2. Litter Costs	costs associated with litter pick-up along rights-of-way	a dense growth of roadside wildflowers decreases visibility of litter and results in decreases in litter pick-up costs [18]
3. Spraying and Mowing Costs	costs associated with standard chemical and mechanical based vegetation management systems	- decreases in area requiring mowing or spraying [25,35] - decreased mowing resulting from use of crown vetch has resulted in approximate overall savings of \$300,000/yr. [61] - costs associated with establishment and maintenance are quite high but savings may be realized when wildflowers are used on sections of right-of-way requiring high level of maintenance [25]
4. Aesthetics	value associated with improved visual appeal	possible increase in tourism [41]

Table 18/ Costs/Benefits of Policy Option D: Candidate Program 2

Policy Option D: To Improve Aesthetic Quality of Rights-of-way Candidate Program 2: Increase Visual Diversity and Visual Appeal		
Costs	Description of Costs	Comments
A. Site and Plant Material Selection		
1. Experimentation and Research	evaluation and matching of site and species characteristics	will vary with range of site conditions and range of plant species being considered
B. Planting and Establishment		
1. Education and Training	training of Ministry staff regarding planting and maintenance techniques	offered on an "as-needed" basis, frequency and costs will decrease as experience and knowledge become established at district-level or crew level
2. Site Preparation and Planting	preparing site and planting (including removal of existing vegetation)	- may require spraying, mowing, plowing, discing - least expensive on construction sites [25] - more expense and effort put into proper site preparation and planting, decrease future costs for plantings
3. Stock Purchase	costs of purchasing plant material	can be expensive and difficult to obtain appropriate species, sizes, vigour [25]
C. Maintenance		
1. Education and Training	see Planting and Establishment	see Planting and Establishment
2. General	post-planting activities aimed at ensuring survival and visual appeal of plantings	- high maintenance costs offset by decrease in costs for new plantings - more expense incurred in site and species selection, site preparation and planting, lower the maintenance costs [25,40,59] - high costs composed of monitoring and inspection, maintenance labour, watering, fertilizer, re-seeding
Benefits	Description of Benefits	Comments
1. Aesthetics	value of providing aesthetically pleasing right-of-way	increased survival will increase aesthetics and be positive for tourism
2. Mowing and Spraying	costs associated with chemical and mechanical vegetation management	- can decrease the area requiring mowing or spraying - use of tree and shrub plantings with wood chips cut mowing costs by 25% [61]

Table 19/ Costs-Benefits of Policy Option E: Candidate Program 1

Policy Option E: To Develop a New Approach to Dealing with the Public		
Candidate Program 1: Publicize Past Initiatives		
Costs	Description of Costs	Comments
1. Education and Training	• costs associated with training Ministry staff	• costs will depend on the extent of the proposed publicity program
2. Project Supervision, Administration	• costs associated with introducing new publicity program (staffing, etc.)	
3. Production and Dissemination of Information Packages	• costs associated with producing and distributing education or promotional literature	
Benefits	Description of Benefits	Comments
1. Public Awareness	• value of increased public awareness with respect to Ministry programs	• may garner public support for current and future program initiatives
2. Complaints	• costs associated with response to complaints from public	• effective publicity will decrease the number of public complaints and decrease Ministry staff time currently devoted to responding to complaints

Table 20/ Costs/Benefits of Policy Option E: Candidate Program 2

Policy Option E: To Develop a New Approach to Dealing with the Public		
Candidate Program 2: Organize New Initiatives Including "Adopt a Highway" Scheme, Education Regarding Pesticide Use, and Sustainable Development		
Costs	Description of Costs	Comments
1. Education and Training	• costs associated with training Ministry staff	• costs will depend on the extent of the proposed initiatives program
2. Project Supervision, Administration	• costs associated with introducing new publicity program (staffing etc.) including supervision of public participants	
3. Production and Dissemination of Information Packages	• costs associated with producing and distributing education or promotional literature	
Benefits	Description of Benefits	Comments
1. Public Awareness	• value of increased public awareness with respect to Ministry programs	• may garner public support for future program initiatives
2. Complaints	• costs associated with response to complaints from public	• effective publicity will decrease the number of public complaints and decrease Ministry staff time currently devoted to responding to complaints • effective responses to public concerns will decrease damage claims [24]
3. Public Involvement	• value of increased public involvement in programs	• potential reduction in Ministry labour costs for vegetation management (see Policy Option E: Candidate Program 3)
4. Environmental Quality	• improvements in environmental quality	• reductions in mowing and spraying resulting from public labour, reduce pesticide residues in environment

Table 21/ Costs/Benefits of Policy Option E: Candidate Program 3

Policy Option E: To Develop a New Approach to Dealing with the Public Candidate Program 3: Involve Public in Roadside Vegetation Management		
Costs	Description of Costs	Comments
1. Education and Training	• costs associated with training Ministry staff	• will vary depending on type of project
2. Project Supervision, Administration	• costs associated in supervision of projects and public participants	• will vary depending on size and type of project (minimum for projects involving individual landowners maintaining areas adjacent to property, maximum for public groups involved in establishment and maintenance of right-of-way plantings)
3. Accidents	• costs associated with safety and liability with regard to accidents involving public participants	• liability minimized through supervision, training, and written waivers [25]
Benefits	Description of Benefits	Comments
1. Public Awareness	• value of increased awareness with respect to Ministry programs	• garners public support for future program initiatives
2. Labour	• impact on Ministry labour	• overall decrease in Ministry staff time
3. Plant Material	• costs of plant material for landscaping	• donations of money or plant material decreases Ministry cost of obtaining plants [25]
4. Plant Survival	• impact on survival of plant material	• often survival increases due to intensive maintenance
5. Aesthetics	• visual appeal of right-of-way	• often aesthetics increase due to increased survival of plantings, intensive maintenance • increased number and diversity of plantings
6. Free Publicity	• free media publicity on Ministry programs and public involvement	• improves public knowledge and understanding of programs
7. Agricultural Products	• see Policy Option C: Candidate Program 1	• use of right-of-way by adjacent farmers can increase total production from farm operation by harvesting products from right-of-way or using right-of way for equipment movement, turning, etc.
8. Mowing, Spraying	• costs associated with chemical or mechanical vegetation management	• increase in area planted, in agriculture, or managed by local landowners - decreases area requiring mowing or spraying by Ministry

Table 22/ Total annual cost, area, and cost per hectare of mowing activities by the Ministry of Transportation in Ontario for 1987/88 and 1988/89
(source: Ministry of Transportation maintenance operations reports - computer printouts)

Activity	1987/88			1988/89		
	Total Cost (\$)	Total Area (ha)	Average Cost (\$/ha)	Total Cost (\$)	Total Area (ha)	Average Cost (\$/ha)
Mowing right-of-way	1 151 793	9 386	122.71	951 688	9 952	95.63
Mowing adjacent to the shoulder	588 153	8 820	66.68	563 836	8 577	65.74
Hand mowing	452 370	—	—	455 192	—	—
Total	2 192 316	18 206	—	1 970 716	18 529	—

Table 23/ Total annual cost, area, and cost per hectare of chemicals sprayed by the Ministry of Transportation in Ontario for weed control during 1987/88 and 1988/89
(source: Ministry of Transportation maintenance operations reports)

Chemical	Truck Mounted						Tractor Mounted					
	1987/88			1988/89			1987/88			1988/89		
	Total Cost (\$)	Area (ha)	Avg Cost (\$/ha)	Total Cost (\$)	Area (ha)	Avg Cost (\$/ha)	Total Cost (\$)	Area (ha)	Avg Cost (\$/ha)	Total Cost (\$)	Area (ha)	Avg Cost (\$/ha)
Tordon	133 362	1 296	102.90	104 857	1 112	94.30	--	--	--	--	--	--
2,4-D	13 107	132	99.30	6 814	170	40.08	43 170	--	--	20 336	323	62.65
2,4-D/ DICAMBA	389 634	4 550	85.63	387 666	5 098	76.03	32 160	485	66.31	36 091	513	70.35
2,4-D/2,4-DP	285 826	8 602	33.23	199 650	4 317	46.25	55 781	985	56.63	56 017	1 182	47.39
Glean	--	--	--	20 328	--	--	--	--	--	--	--	--
Total*	821 929	14 580	56.37	698 987	10 698	65.34	31 111	1 470	59.82**	12 444	2 018	55.72

* Excluding Glean

** Average for 2,4-D/Dicamba and 2,4-D/2,4-DP only

Table 24/ Total annual cost, area, and cost per hectare of chemicals sprayed by the Ministry of Transportation in Ontario for brush control, during 1987/88 and 1988/89
(source: Ministry of Transportation maintenance operations reports)

Chemical	1987/88			1988/89		
	Total Cost (\$)	Area (ha)	Cost/Area (\$/ha)	Total Cost (\$)	Area (ha)	Cost/Area (\$/ha)
Tordon	421 565	1 544	273.03	423 232	1 690	250.43
2,4-D/2,4-DP	237 741	2 116	112.35	249 737	2 198	113.62
Total	659 306	3 660	180.14	672 969	3 888	173.09
			Avg			Avg

Table 25/ Total annual cost, and accomplishment for planting and establishment of vegetation by the Ministry of Transportation in 1987/88 and 1988/89 in Ontario
(source: Ministry of Transportation maintenance operations reports)

Activity	1987/88		1988/89	
	Total Cost (\$)	Accomplishment	Total Cost (\$)	Accomplishment
Tree Planting and Establishment	19 669	370 trees	88 205	1878 trees
Shrub, Seedling, Planting and Establishment	4 780	-	8 503	-
Grass Seeding	32 357	33 ha	29 620	13 ha
Total Woody Species Planting and Establishment	24 449	-	96 708	-
Total Planting and Establishment	56 806	-	126 328	-

Table 26/ Total annual cost for maintenance of plantings by the Ministry of Transportation in 1987/88 and 1988/89 in Ontario
(source: Ministry of Transportation maintenance operations reports)

Activity	1987/88 Total Cost (\$)	1988/89 Total Cost (\$)
Maintenance of Trees, Shrubs and Seedlings	408 772	508 120

Table 27/ Ontario Ministry of Transportation capital expenditures on seeding and mulching and tree and shrub planting

Seeding and Mulching				
Year	Area Seeded (ha)	Quantity of Primary Seed (kg)	Expenditure (\$)	Cost per Area (\$/ha)
1986	240.6	24 057.80	651 728.06	2 708.76
1987	242.8	24 281.15	741 269.22	3 053.00
1988	202.2	20 221.20	620 648.05	3 069.48
1989	198.2	19 824.00	593 715.98	2 995.54

Tree and Shrub Planting	
Year	Expenditure (\$)
1988	502 400
1989	567 300
1990	659 000

Provided to Ecologistics Limited by Ministry staff, February 26, 1990.

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